IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

UNDERSTANDING TEMPERATURE EFFECTS ON PV SYSTEM PERFORMANCE

Compiled for **IEA PVPS Task 2** by:

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in co-operation with Task 2 members from Austria, Germany, Italy and Japan.

Introduction

Within the framework of Task 2 of the Photovoltaic Power System Programme (PVPS) of the International Energy Agency (IEA) performance results of 190 grid-connected PV systems in different countries have been compared [1] [2]. In this paper the effect of the elevated cell-temperature on the annual performance of 18 selected grid-connected PV systems of different mounting (freestanding, roof-mounted and integrated PV facades) from different geographic location in 5 countries are analysed. Annual datasets of hourly data have been used for this in depth analysis.

Plants investigated

The 18 grid connected PV plants investigated are located in Austria, Germany, Italy, Japan and Switzerland. The monitored data was supplied by the Task 2 members of each country.

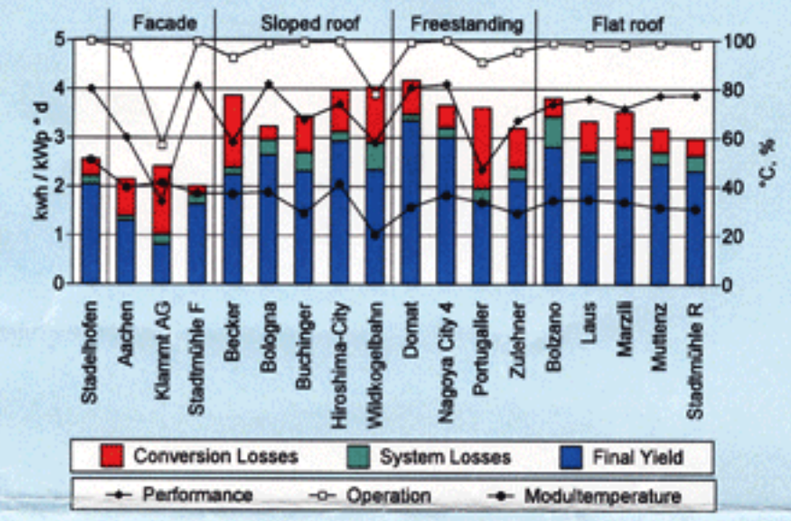


Figure 1, shows the annual values of the normalised losses and yields, the performance, the availability and the module temperature of the 18 plants analysed.

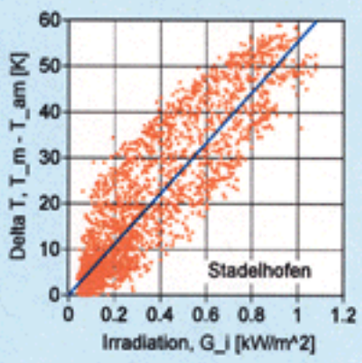
The types of mounting are grouped in 4 main types:

- Facade (integrated)
- Sloped roof
- Freestanding
- Flat roof

The following figures show the rise of the module temperature ($T_m - T_{am}$) in respect to the irradiation for the different types of mounting. The figures represent hourly values during the operation of the plant over one year. For each type of mounting two samples are shown, usually one with high and one with a low rise in module temperature from ambient.

Sloped roof, highly integrated

Figure 2, the plant Stadelhofen in Switzerland shows a high module temperature. The cells are mounted inside a compound insulation glass cover on a slightly sloped roof. It seems that there is little air circulation inside the building in the roof area. The maximum measured module temperature was 85 °C and the mean rise in temperature from ambient is about 55 K at 1000 W/m². This results in a loss of 10.3 %.



Facade, integrated

The typical rise in module temperature from ambient for an integrated facade system is between 48 and 54 K and the annual temperature losses are between 4.2 and 6.1 %.

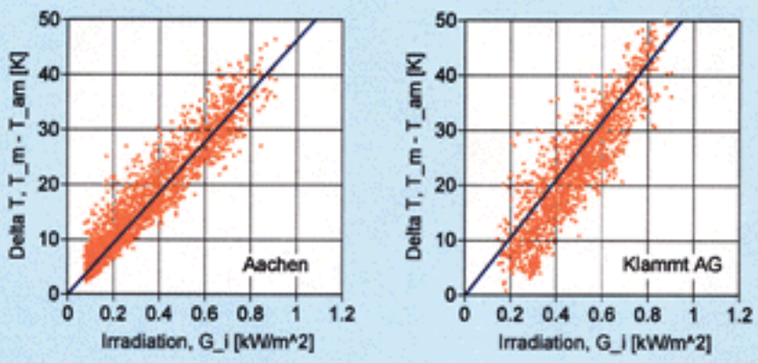


Figure 3, shows the module temperature of two systems in Germany. The plant Aachen is well cooled and the plant Klammt AG is isolated and has a narrow air-gap for cooling and therefore a higher module temperature.

Sloped Roof

The cooling of a PV array mounted in a sloped roof depends on the level of integration or the air-gap between the roof and the modules.

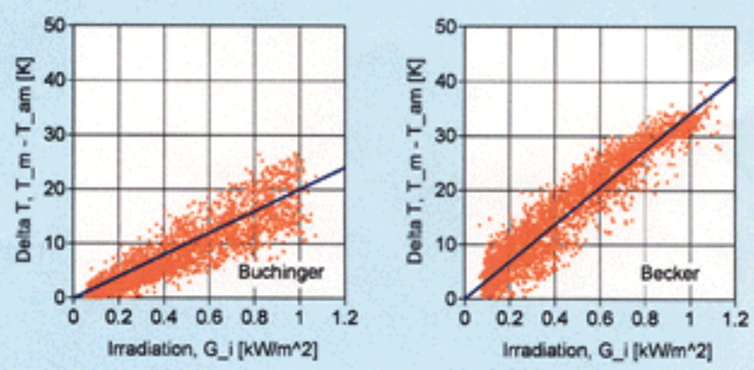


Figure 4, is an example of a well cooled and not so well cooled roof system. The range of the rise of temperature from ambient in the systems investigated is between 21 and 34 K and the annual temperature losses range from 1.4 to 6.6 %. One alpine roof system in Austria (Wildkogelbahn) , due to low ambient temperature, showed a gain of 2.9 %.

Freestanding and Flat Roof

Freestanding and flat roof systems usually allow a free airflow around the modules and have therefore lower temperature losses. Of the freestanding and flat roof systems analysed the temperature rise is between 21 and 31 K and the annual temperature losses between 1.2 and 4.7 %

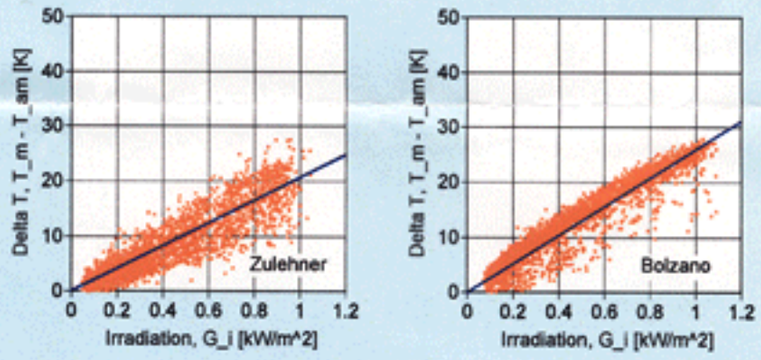


Figure 5, shows the module temperature data of two freestanding systems.

Conclusion

Of the 18 systems analysed 17 showed an annual temperature loss ranging from 1.2 to 10.3 %. The annual average daytime temperature for all the PV systems is between 2 and 21 °C. A well cooled PV array can have a temperature rise of about 25 K at 1000 W/m² and a temperature loss of less than 4 %.

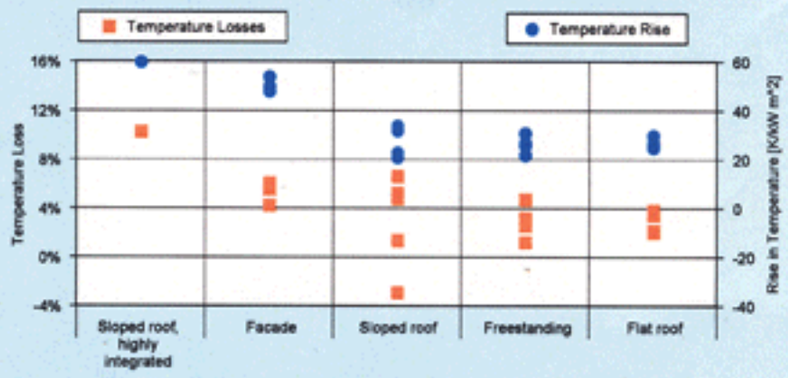


Figure 6, is an overview of the results of all the 18 PV systems, showing the annual temperature losses and the rise in moduletemperature from ambient (K at 1000 W/m²).

References

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